POTATO HOPPERBURN (TIPBURN) CONTROL WITH BORDEAUX MIXTURE

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Agricultural Experiment Station

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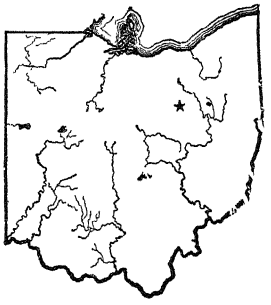

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[1]In cooperation with the College of Agriculture, Ohio State University, Columbus.
[2]In cooperation with the U. S. Department of Agriculture.

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BULLETIN
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POTATO HOPPERBURN (TIPBURN) CONTROL WITH BORDEAUX MIXTURE

T. H. PARKS[1] AND E. E. CLAYTON[2]

A seasonal potato spraying schedule with bordeaux mixture was outlined by the authors, and its application directed during 1921 and 1922 on 92 farms and in 14 counties in Ohio.[3] The purpose of the spraying program was to demonstrate the value of this spray in increasing the yield of potatoes, when applied thoroughly and following a definite schedule. The seasons of 1919 and 1920 had brought heavy losses from hopperburn[4]. Late blight caused some damage in northwestern counties in 1920. The bordeaux spraying program was developed to prevent as much as possible of either or both of these troubles, should they again appear. Late blight did not appear in either 1921 or 1922. Early blight was not serious in any locality. Hopperburn was quite severe in both years and was largely responsible for the premature death of the potato tops in all unsprayed fields. Since it was so prevalent during both seasons, the results secured were almost entirely tests of the control of that trouble.

SPRAY MATERIALS AND METHODS USED

Home-made liquid bordeaux mixture (5-7½-50) was applied to both upper and under sides of the foliage. The spraying was commenced when the plants were 6 to 10 inches high and repeated at approximately 2-week intervals. Two, three, four, five, and six

[1]Extension Entomologist, Ohio State University.
[2]Extension Pathologist, Ohio State University, resigned July 1, 1922.
[3]This work took the form of community demonstrations and was conducted through the cooperation of the county agricultural agents, without whose help it would not have been possible.
[4]The term "hopperburn" is used instead of "tipburn" since it more closely associates the condition with the cause (potato leafhopper), and also to distinguish this damage from a supposedly physiological condition affecting only the leaf tips and not yet associated with insect damage.

applications were made in order to determine the most profitable number. Arsenate of lead powder 2½ pounds to 50 gallons of water was added to the first application to kill the hatching Colorado potato bugs. When necessary, the check plots to be left unsprayed were treated with arsenate of lead alone to kill the hatching Colorado potato beetles. The tests were to demonstrate the value of the bordeaux mixture applied after a schedule and the results can be accredited to it alone. Commercial potato growers who owned suitable sprayers, cooperated in making these tests and applied the mixture under conditions and in such manner as any grower of potatoes can follow. In 1921 sixty tests and in 1922 seventy tests were made where check rows were left unsprayed and the yields compared.

EQUIPMENT FOR SPRAYING

The spray machines used were of three kinds as follows: (a) gasoline power, (b) geared traction, and (c) hand pump sprayers. In all cases the spray machines were equipped with three nozzles per row, two spraying upward at an angle of about 60 degrees, and one downward on the tops. The result was a fairly uniform covering of bordeaux mixture on many of the lower, as well as the upper, surfaces of the leaves. The gasoline power sprayers maintained a pressure of 175 to 225 pounds. The hand pump and geared traction sprayers held a pressure of 60 to 150 pounds, depending upon the machine and number of nozzles it carried.

A very good covering of the foliage was secured by using hand rods equipped with three nozzles and guided along the row by the operators standing on the sprayers. (Fig. 5.)

HOPPERBURN THE ONLY SERIOUS TROUBLE

Hopperburn, the only serious trouble that appeared during the tests, proved to be very severe and to be generally distributed over the State. Hopperburn is characterized by the dying of the tips and edges of the potato leaves, followed by the rolling of the blackened edges. Soon, only the middle portion of the leaf remains green and performs its function and a little later the entire leaf dies. The stems remain green but a few days after the death of the foliage. During 1921 the damage was so severe that the plants in unsprayed fields died before the tubers were mature. Though less prevalent in 1922 than in 1921, hopperburn was present over the entire State. The foliage was seriously damaged before the crops matured, and in most cases the yields were visibly reduced.

RELATION OF LEAFHOPPER TO HOPPERBURN

A small green insects known as the potato leafhopper (*Empoasca mali* LeB.), is now known to be associated with the premature dying of the tips and edges of the leaves. The adults (Fig. 1) are small, pale green, jumping insects about 1/8 inch long. These are known to winter in dense grass, weeds, and undergrowth. They feed on apple and other host plants during the spring, and enter the early potato fields in June and July. Eggs are laid in the mid-ribs and stems of the potato leaves and hatch in about 10 days. The young leafhoppers (Fig. 2) are light green and wingless. They feed only on the underside of the leaves and when disturbed run with a sideways movement across the leaf, or if nearly grown, hop from one leaf to another. They feed by sucking the sap from the larger veins, thus affecting the entire leaf.

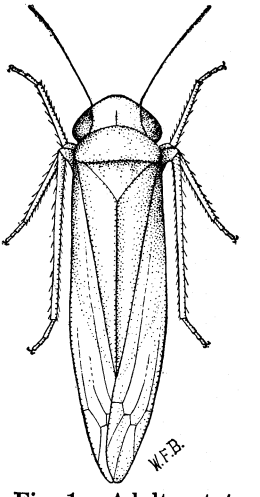

Fig. 1.—Adult potato leafhopper (Empoasca mali LeB.)

There are known to be two full generations of the insects each year on potatoes. After the middle of July the insects are present in all stages, so that the generations are difficult to distinguish, young and adults being always present. They increase rapidly in numbers throughout late summer and may become quite abundant by September.

After the vines are dead the insects which have matured, leave the potato fields for other host plants and return again the following summer.

THE DISEASE

Little is known about the disease if, as is apparent, the condition is pathological. The causative organism has never been observed, but is very evidently dependent upon one species of leafhopper and no other insect for its living over winter and transmission to potato. Plants growing in fields known to have hopperburn during the previous season do not become affected unless exposed to the leafhoppers and fed upon by them. According to Ball[5], only leaves which are fed upon develop hopperburn, while other leaves on the same plant remain healthy. Since practically all upsprayed leaves were fed upon, very few undamaged leaves were present in Ohio during 1921 and 1922. The disease develops under all kinds

[5]Ball, E. D., Wisconsin Dept. Agr. Bul. No. 23, 77, 1919.

of soil and weather conditions, but progresses most rapidly during periods of hot, dry weather, during which it may cause the rapid death of the plants.

SEASONAL DEVELOPMENT OF INSECTS AND DISEASE

In 1920 the adult leafhoppers were present in plentiful numbers in potato fields of central Ohio by June 22. No nymphs (young) were present then. Early Triumph potatoes were visibly affected with tipburn at that date. The disease progressed rapidly throughout July, but owing to plenty of moisture, all early varieties except Triumph stood up well and matured a fair crop. Late varieties became infested with leafhoppers in July and were damaged by hopperburn during August and September.

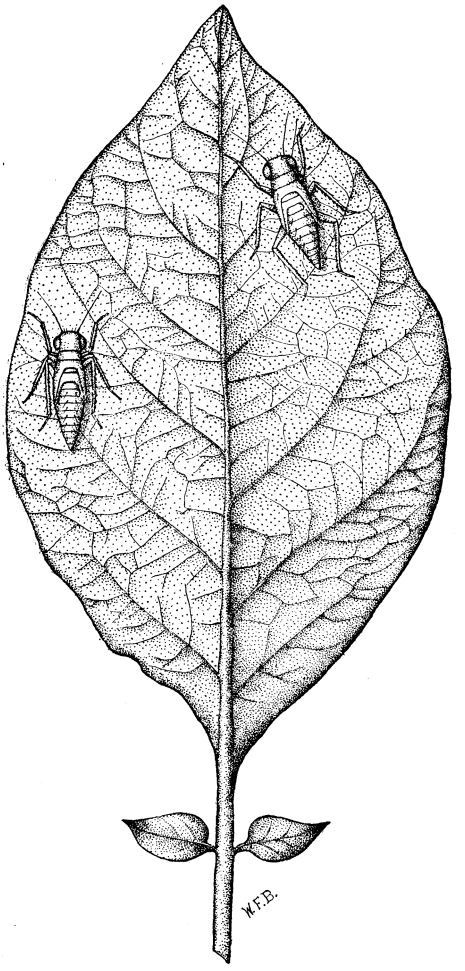

Fig. 2.—Young potato leafhoppers on leaf

In 1921 adults were first noticed in central Ohio potato fields May 26, and had migrated into the fields in plentiful numbers by June 9. Young leafhoppers were hatching on the potatoes on the 14th, two weeks earlier than in 1920, and were becoming numerous by the 19th. Hopperburn was developing rapidly July 10, and in most fields which were sprayed with bordeaux, the unsprayed check rows could at that time be distinguished readily from the sprayed rows by an observer located at a distance of 20 to 30 rods. The plants in the check rows left unsprayed were rapidly deteriorating. On July 20, about 90 percent of the plants in unsprayed rows were dead in the test fields of early varieties.

By August 1 the plants in the unsprayed rows were all dead, and by the 15th those in the sprayed fields had also succumbed to the influences of hopperburn.

Late varieties became infested with leafhoppers when the plants were about 12 inches high, whether they were planted in May, June, or July. The accumulative effect of the feeding of the insects and of the progress of the disease was the same as observed for early potatoes. Late varieties were able to withstand the hop-

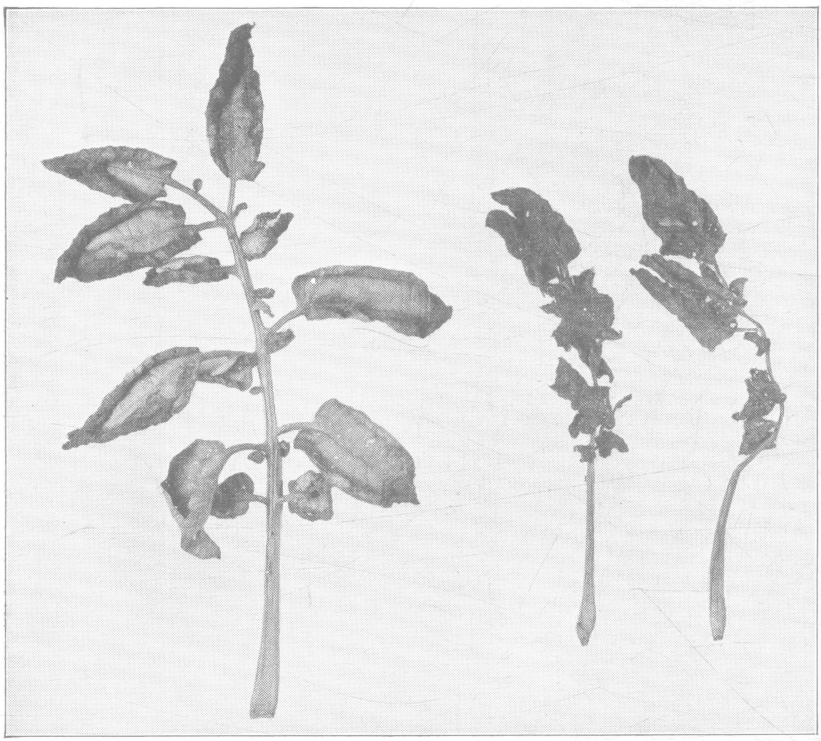

Fig. 3.—Potato branch on left shows typical hopperburn damage. The branches on the right show the advanced stages of hopperburn

perburn better than early varieties because of the better growing weather after they became infested. Many fields of unsprayed late varieties were dead from hopperburn by September 15, though there were no killing frosts until several weeks later. During this time the sprayed potatoes, suffering much less damage, continued to grow.

In 1922, the growth of early planted potatoes was retarded by drouth in June, at which time hopperburn was becoming prevalent. The light crop, harvested in July was due to the combined influence

of dry weather and hopperburn. Tubers planted in June had more favorable growing weather, and with hopperburn less severe than in 1921, the tops, although damaged, remained green until killed by frosts. Sprayed foliage did not show much difference from that in the unsprayed check rows until about three weeks before maturity when the unsprayed plants rapidly deteriorated under the attack of the leafhoppers.

SUSCEPTIBILITY OF VARIETIES

All varieties of potatoes which came under our observation were seriously affected with hopperburn. Of the early varieties, Early Triumph proved to be by far the most susceptible. During 1920 this variety succumbed so rapidly under the attack of this disease that the yield secured scarcely equalled the seed planted. Early Ohio growing adjacent was much less affected, but this variety was found to be quite susceptible and probably incurs more loss from hopperburn than any other variety generally grown in the State. Irish Cobbler was least affected of the early varieties. This variety gave larger increases in yield for bordeaux spraying than did Early Ohio when grown and sprayed under the same conditions.

Of the late varieties observed, none were found to be immune to hopperburn. Varieties of the Green Mountain type were able to stand up under the attack much better than the Rural varieties, but this was probably due to the larger amount of foliage possessed by the Green Mountain potatoes. With more leaf surface to feed upon, and the same number of leafhoppers present, the hopperburn was scattered over a larger area of leaf surface with less resulting damage. Injury to the Green Mountain type was severe, however, and some of the best results for spraying were secured with this variety.

Rural New Yorker and Sir Walter Raleigh were both seriously affected by the disease and both responded well to spray treatment. Scarcely any leaves of these varieties were undamaged in unsprayed fields in 1921 when they succumbed to the disease from three to four weeks before killing frosts.

SPRAYING RESULTS IN POTATO FIELDS

In 1920 attempts were made to kill the adult leafhoppers before the nymphs hatched and the appearance of leaf damage. Spray applications were made at intervals of approximately two weeks to both sides of the foliage and as thoroughly as practicable

under field conditions. A ten percent solution of kerosene emulsion was first used. This was not successful, practically all of the adults surviving the spray. Bordeaux mixture, carrying nicotine sulphate (one part to 500 of bordeaux), was next tried after some of the wingless young leafhoppers were hatched. Some of the young insects were killed, but the results were little better than when bordeaux mixture was used alone. It was apparent that bordeaux mixture alone was the most reliable.

Fig. 4.—A good spray covering with bordeaux. Four rows on right unsprayed

During 1921, sixty field tests were made relying upon 5-7½-50 homemade liquid bordeaux mixture to give control. These were commenced in southern Ohio in May and finished in northern counties in September, and were made under a wide variety of soil and weather conditions. The resulting yields varied but were decidedly in favor of the spraying. Only four of the sixty tests gave no gain in yield for spraying, while the average increase for all tests was 31.6 bushels per acre. One Cuyahoga County grower received 82 bushels per acre increase for applying five sprays. Gasoline power sprayers gave an average increase of 39½ bushels per acre in twenty-seven tests, and geared traction sprayers gave an average increase of 24 bushels per acre in twenty-nine tests.

During 1922[6] seventy field tests were made in thirteen counties, 5-7½-50 home-made liquid bordeaux mixture again being

[6]N. W. Glines assisted in directing the spray program for 1922 in Scioto and Hamilton Counties.

used. Many growers who cooperated the year previous, continued their spraying, being convinced of its value from the first year's work, but did not leave check rows unsprayed. Nearly all of the power sprayers used were owned cooperatively by spray rings, usually one or more members of the ring leaving check rows unsprayed to determine the spray value. During this year only two cooperators received no increase for spraying, while one who sprayed four times increased his yield 96.8 bushels per acre. The average increase per acre for spraying where power sprayers were used was 33 bushels, and traction sprayers 30 bushels.

During both years a severe drouth occurred in mid-summer which cut short the yields of all early varieties, both sprayed and unsprayed. Protection of the leaves by spray could not compensate for lack of moisture in the soil. However, in the midst of this drouth, the sprayed plants remained alive longer than the unsprayed plants. The unsprayed rows could be picked out by their general appearance when viewed at a distance. In two such fields counts were made on July 19 and 20, 1921, to determine the percentage of living and dead plants in sprayed and unsprayed rows. The results are here given:

TABLE 1.—EFFECT OF BORDEAUX MIXTURE UPON POTATO PLANTS

County	Variety	Dates sprayed	Dates examined	Condition of plants, percent	
				Unsprayed rows	Sprayed rows
Franklin	Early Ohio	June 11 June 28	July 19	10 alive 90 dead	36 alive 64 dead
Greene	Early Ohio	May 31 June 14 July 5 July 12	July 20	29 alive 71 dead	65 alive 35 dead

While satisfactory increases for spraying were secured under the droughty conditions, they were less than those secured both years with late varieties where good growing weather continued and kept alive the sprayed foliage. Hopperburn injured or completely destroyed the unsprayed late varieties as it did the early ones, and under weather conditions more suitable for the growth of the potatoes.

Spraying paid well, with few exceptions, under both favorable and unfavorable moisture conditions. It is apparent that in years of bad attack the best soil moisture conditions, without spraying, are not able to prevent the death of the plants from the disease.

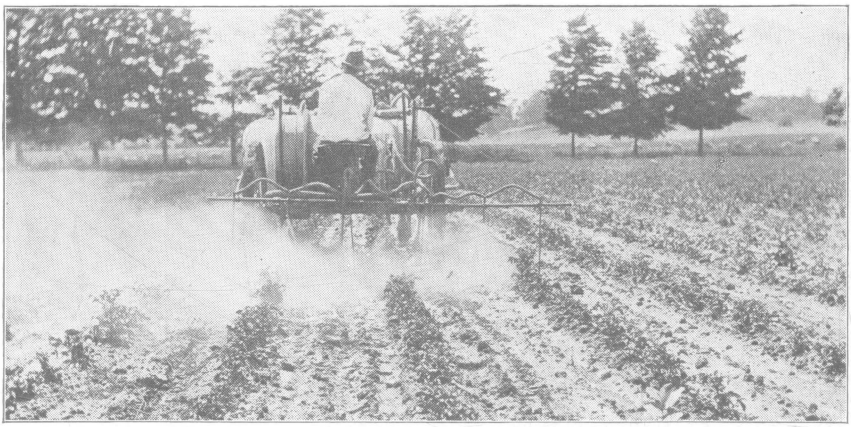

Fig. 5.—Gasoline power sprayer in action

Fig. 6.—Hand power type of sprayer in action

The conclusions from two years' work were that plenty of moisture and good growing weather throughout the latter half of the potato crop's development are conducive to the highest gains for spraying for hopperburn control.

The percentage of marketable potatoes was about the same for the sprayed and unsprayed plots. Spraying increased the yield but the increase was in quantity, not quality of tubers. No exceptions to this were found in any of the tests.

RESULTS FROM DIFFERENT KINDS OF SPRAYERS

The average results from the three different kinds of sprayers used vary in direct proportion to the thoroughness of the spray covering obtained. The gasoline power sprayers were all good machines and kept from 175 to 225 pounds pressure. They required about 100 gallons per acre for each application. The pressure of the geared traction sprayers, geared to the wheel from where they received their power, varied from 75 to 150 pounds. They applied on an average about 75 gallons of spray per acre.

TABLE 2.—AVERAGE INCREASE FROM THE THREE TYPES OF SPRAYERS

Year	Kind of sprayer	Number of tests	Number of sprays	Average increase per acre, bushels	Average increase, percent
1921	Gasoline power	24	3 to 5	40	35
1922	Gasoline power	36	3 and 4	36	34
1921	Geared traction	29	3 to 6	24	27
1922	Geared traction	11	3 and 4	30	28
1921	Hand power	3	3 and 4	38	33
1922	Hand power	6	3 and 4	31	36

Many of these sprayers had seen long service and were made over to spray with three nozzles per row. The hand power sprayers consisted of orchard spray outfits mounted on two wheeled trucks and equipped with two leads of hose fitted with three-nozzle-per-row attachments made especially for them. These rods as well as the pump were operated by hand. They applied approximately 90 gallons per acre per application at a pressure varying from 60 to 120 pounds.

TABLE 3.—INCREASE FROM BORDEAUX MIXTURE APPLIED WITH GASOLINE POWER SPRAYERS

Bushels per acre

County	2 times	3 times	4 times	5 times	6 times	Increase	Net gain per acre
1921	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Percent*	*Dollars*
Cuyahoga	60					58	$ 94.15
Cuyahoga	25					37	34.75
Cuyahoga		72				103	110.60
Cuyahoga		48				80	71.05
Cuyahoga		44				38	65.75
Cuyahoga		32				27	44.95
Cuyahoga		30				50	41.65
Cuyahoga		28				29	37.85
Cuyahoga		0				0	—7.50
Cuyahoga		0				0	—7.50
Cuyahoga			55			80	80.75
Cuyahoga			45			74	64.75
Cuyahoga				82		77	123.65
Cuyahoga				65		48	95.80
Cuyahoga				62		53	89.95
Cuyahoga				52		79	74.30
Cuyahoga				51		39	71.80
Cuyahoga				50		28	71.50
Cuyahoga				37		32	49.05
Cuyahoga				36		24	47.40
Cuyahoga				22		19	25.00
Cuyahoga				18		11	17.05
Cuyahoga				14		12	10.95
Portage	14.5					7	13.20
Portage		17				13	15.35
Portage			69.5			61	94.25
Portage			39			49	48.65
1922							
Cuyahoga	18.5					36	9.80
Cuyahoga	11					14	3.65
Cuyahoga		57				75	38.10
Cuyahoga		44				107	27.55
Cuyahoga		38				24	22.90
Cuyahoga		28				31	15.20
Cuyahoga		26				33	13.85
Cuyahoga		26				37	12.95
Cuyahoga		22				9	10.35
Cuyahoga		22				22	10.25
Cuyahoga		18				30	6.90
Cuyahoga		17				10	6.10
Cuyahoga		13				10	3.05
Cuyahoga		12				9	2.60
Cuyahoga		8				8	—.70
Cuyahoga		8				9	—.75
Cuyahoga		0				0	—7.50
Cuyahoga			97			92	67.35
Cuyahoga			66			50	42.80
Cuyahoga			63			75	40.65
Cuyahoga			63			64	40.25
Cuyahoga			52			25	31.85
Cuyahoga			30			35	14.00
Cuyahoga			28			37	12.70
Cuyahoga			25			18	10.15
Cuyahoga			21			12	6.80
Cuyahoga			8			6	—3.50
Portage		59				32	39.70
Portage		45				30	30.75
Portage		34				23	20.20
Portage		32				37	18.40
Ashtabula	45					49	31.40
Ashtabula		58				64	39.30
Ashtabula		20				12	8.50
Ashtabula			65			38	42.00
Stark			43			19	33.20
Erie				84.5		44	50.95
Greene			18.5			8	8.40
Greene					54.5	26	39.40
Butler	10					19	8.75
Butler	7.5					10	1.80
Butler	3.5					6	—2.30
Average.....	21.7	28.7	46.4	47.8	54.5	35	33.14

TABLE 4.—INCREASE FROM BORDEAUX MIXTURE APPLIED WITH GEARED TRACTION SPRAYERS

Bushels per acre

County	2 times	3 times	4 times	5 times	6 times	Increase	Net gain per acre
1921	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Percent*	*Dollars*
Clarke		16				17	28.00
Clarke		4				5	1.70
Clarke		0				0	—7.50
Cuyahoga		41				36	57.60
Cuyahoga		31				25	42.10
Cuyahoga		30				68	41.50
Cuyahoga		26				39	35.90
Cuyahoga		21				44	25.30
Cuyahoga		18				15	21.90
Cuyahoga		15				12	15.85
Cuyahoga		6				5	1.45
Cuyahoga		5				13	.95
Cuyahoga				28		19	32.80
Cuyahoga				19		29	18.40
Cuyahoga					76	67	73.35
Cuyahoga					56	45	75.75
Cuyahoga					52	40	69.65
Cuyahoga					15	37	11.30
Cuyahoga					0	0	—15.00
Erie			52			26	62.80
Erie			10			3	7.50
Greene			29			60	54.35
Greene				29		50	53.75
Lake		8				11	5.10
Lake		4				10	—1.60
Lake					38	58	46.65
Lake					19	18	16.80
Lake					14	20	8.55
Wayne			38			21	47.75
1922							
Ashtabula	28					17	17.65
Clarke			21			17	11.25
Erie		3				1	—4.40
Erie			53			65	32.90
Erie			11			9	—.80
Erie				18		9	2.30
Erie				11		17	—3.70
Hamilton	32					35	35.00
Hamilton		37				19	39.00
Hamilton		27				20	19.50
Hamilton		26				46	45.50
Stark		63				28	55.40
Tuscarawas			25			25	15.00
Wayne				63		40	35.25
Wayne				27		17	8.00
Average	30.2	20.2	30.1	28.1	38.8	26	25.92

COST AND PROFITS FROM SPRAYING WITH BORDEAUX MIXTURE

Members of a Portage County spray ring, owning cooperatively a gasoline power sprayer and spraying 50 acres of potatoes, found their cost in 1921 to be $2.54 an acre per application. This included materials, labor, depreciation on machine, and interest on investment. Cuyahoga County rings in 1922 found their cost to be approximately $2.50 an acre per application. For geared traction sprayers, the cost was between $2.00 and $2.50 an acre per application, the depreciation and interest charges being less than for power outfits. In calculating net profits, $2.50 was used as the cost of a single application of spray to each acre. Potato prices used were the average prices received by the growers.

TABLE 5.—INCREASE FROM BORDEAUX MIXTURE APPLIED WITH HAND POWER SPRAYERS

Bushels per acre

County	2 times	3 times	4 times	Increase	Net gain per acre
1921	*Bu.*	*Bu.*	*Bu.*	*Percent*	*Dollars*
Ashtabula			67	68	90.05
Ashtabula			30	27	35.00
Franklin	23			19	41.75
Scioto		18		13	16.50
1922					
Scioto	30			17	32.50
Scioto	12			16	7.10
Scioto	0			0	−5.00
Scioto		66		81	74.50
Scioto		44		35	36.70
Scioto		25		19	23.75
Scioto			23	37	13.15
Scioto			20	29	19.70
Butler		10		14	2.89
Average	16	34	35	29	29.90

In 1921, the average net profit per acre for spraying was $41.58. In 1922, owing to the low market price of potatoes, this was reduced to $20.40. These figures are low compared with those obtained for bordeaux spraying in years when late blight appears to injure the unprotected foliage. The fact that bordeaux spraying paid well, in the absence of blight and with a depressed potato market, marks it as a sound yearly practice for Ohio potato growers.

EXPERIMENTS WITH POTATO DUSTING MIXTURES

Fourteen tests against hopperburn were made in 1921, applying the dusting bordeaux mixture alone and in combination with nicotine dust and arsenicals. These applications were made at intervals of two weeks, and in some fields checked against applications of liquid bordeaux as well as against untreated rows.

The control of hopperburn secured from dust applications, when applied by means of either hand blower or power duster, was greatly inferior to that secured by the spray. In some cases the dusted plots gave no increase over the untreated checks. Ten and twenty pounds per acre per application were applied. Table 3 shows the comparison of two bordeaux dusts with liquid bordeaux mixture (5-7½-50) spray and with untreated checks. In this case the dust was applied each time with a hand blower gun early in the morning. The dusts did not adhere well to the foliage, and when

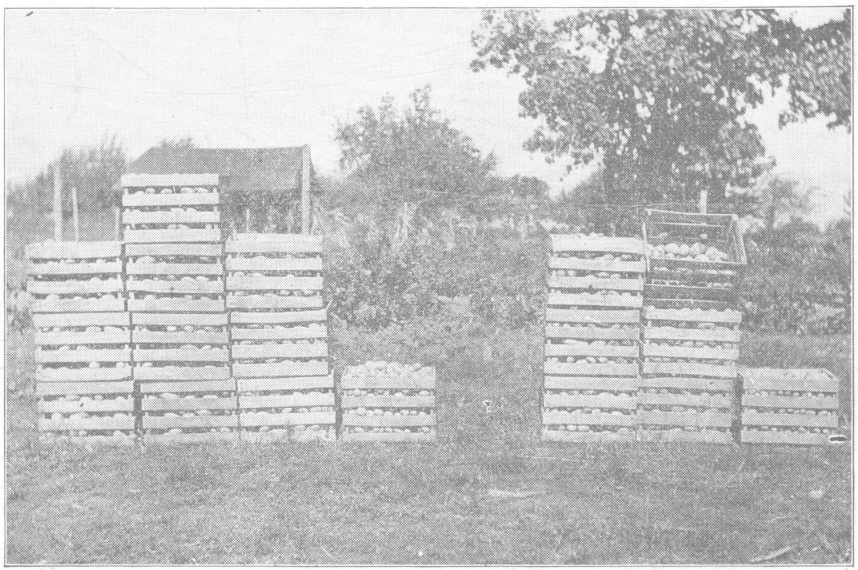

Fig. 7.—Potatoes on left sprayed 4 times, 184 bushels per acre
Potatoes on right unsprayed, 114 bushels per acre

good results from the spraying were visible, the dusted plots appeared in very little better condition than the untreated checks. One-twentieth-acre plots were used in the tests.

Tests with bordeaux dust containing 1.9 percent of nicotine were very unsatisfactory and the combination did not kill nor repel the leafhoppers. In five tests of this mixture applied with a Niagara power duster the average increase in yield for the dusting was but 6½ bushels per acre over the untreated plots. Subtracting the cost of the dusting material and the expense of application, we have a net loss of $5.25 per acre for the method.

The average net gain for dusting in fourteen tests was $2.13 per acre compared with a gain of $41.58 per acre for sixty spraying tests. From this experience we may cnclude that dusting with bordeaux mixture, either with or without nicotine, for the control of hopperburn, is much less effective than spraying, and that the expense at present is too great to justify its recommendation.

TABLE 6.—SPRAYING AND DUSTING WITH BORDEAUX MIXTURE ON THE FERGUSON-GENTNER FARM, GREEN COUNTY, OHIO, 1921

Plot	Variety	Treatment*	Applications†	Yield per acre	Increase per acre	Value of increase	Net gain per acre
			No.	*Bu.*	*Bu.*	*Dollars*	*Dollars*
1	Early Ohio	None	.....	58.9	.....	.....	.....
2	Early Ohio	Liquid bordeaux	5	87.9	29.0	65.25	53.75
3	Early Ohio	Bordeaux dust (Corona, 18% Cu.)	5	72.7	13.8	31.05	8.05
4	Early Ohio	Dust mixture (Niagara)	5	69.4	10.5	23.60	3.60
5	Russet	None	.....	48.7	.....	.....	.....
6	Russet	Liquid bordeaux	4	77.3	28.6	64.35	54.35

*The dusts were applied at the rate of 20 pounds per acre per application.
†Applications made at two-week intervals throughout the season.
‡Potatoes were sold at $2.25 per bushel at farm.

SUMMARY

Potato hopperburn is causing heavy losses to the potato crop in Ohio.

The disease is characterized by dying and rolling of the edges of the potato leaves, followed by premature death of the tops.

The potato leafhopper, a small, green, sucking insect, transmits the disease to the plants.

Early Triumph was the most, and Irish Cobbler the least damaged of the early varieties. Green Mountain varieties resisted the attack better than the Rurals, though spraying gave profitable increases for both types.

Bordeaux mixture was found to have value as a control for the insect, and plants coated with this spray developed much less hopperburn than unsprayed plants.

The use of nicotine sulphate in the bordeaux spray did not kill sufficient numbers of leafhoppers to justify the additional expense.

In 1921, following a definite spraying schedule, sixty field tests with 5-7½-50 bordeaux mixture were made in nine counties. The spray machines were equipped with three nozzles per row and applied the spray as thoroughly as practicable from beneath as well as from above.

The average increase in yield from these tests was 31.6 bushels per acre, a net gain of $41.58 per acre for spraying. Fifteen of the sixty tests gave increases of over 50 bushels per acre, and one an increase of 82 bushels.

In 1922, seventy field tests were made in thirteen counties. The average increase in yield for the spraying was 31 bushels per acre. Fifteen of the seventy tests gave increases of more than 50 bushels per acre, and one an increase of 96.6 bushels.

The average net gain per acre for all tests was $30.28. The four applications with gasoline power sprayers in 17 tests secured the highest net gain, and increased the yield 46.4 bushels per acre.

Four or five is usually the most profitable number of applications to make. The last application apparently being the most important for hopperburn control.

Potato dusting mixtures containing dehydrated copper sulphate and nicotine were less efficient in controlling hopperburn than liquid bordeaux mixture. The higher cost of the dusting materials reduced the net gain for dusting to $2.13 per acre.

All applications were made by the growers and under practical field conditions.